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CALIFORNIA INSTITUTE OF TECHNOLOGY

RADIO OBSERVATORY

Owens Valley, California

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7. 960 MC/S OBSERVATIONS OF RADIO SOURCES IN THE SYDNEY CATALOGUE

by

K. I. Kellermann and D. E. Harris

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INTRODUCTION

During March and September 1960, observations were made with the Caltech interferometer of 739 sources listed in the two catalogues of Mills, Slee and Hill[1,2]. The primary purpose of the investigation was to provide this observatory with a 960 Mc/s "finding list" for future measurements of source sizes and precise positions.

The area covered in these observations was:

δ: -50° to -20° α: 17 to 5 hours

δ: -20° to $+10^{\circ}$ α: 0 to 24 hours.

In general, the observations were restricted to sources in the MSH catalogues whose flux density at 86 Mc/s was greater than 15×10^{-26} watts $m^{-2}(c/s)^{-1}$. All sources down to this level were examined with the exception of those in the region 18^h to 24^h, between 0° and -10°.

Most sources were observed near transit for at least four or five minutes at the position given in the Sydney catalogues. This allowed us to observe one 10-degree declination zone each night. The flux density of each source was measured relative to the standard source Hydra A (09-1$\underline{4}$), which was observed each night when possible. When Hydra $\overline{A}$ was not available, 22-1$\underline{7}$ was used as a secondary calibrator. All observations were made at night to avoid effects of solar radiation.

EQUIPMENT

This program was carried out with two equatorially-mounted paraboloids spaced 200 feet (197λ) apart on an east-west baseline, giving a fringe spacing of 18 minutes of arc. The primary beamwidth (48 minutes) is nearly equivalent to that of the Mills cross at 86 Mc/s, and it was felt that position errors of the order given in the MSH catalogues would not seriously affect the flux density measurements.

The two 10 Mc/s IF amplifiers, each with a bandwidth of 5 Mc/s, were followed by a continuous multiplier and detector. Both sidebands were accepted. The excess noise temperature for the receiver was less than 300°K. The sensitivity and stability were such that a source of flux density 0.5×10^{-26} watts $m^{-2}(c/s)^{-1}$ gave a fringe amplitude somewhat larger than the peak to peak noise fluctuations with a 20-second time constant. (Figure 1).

The interferometer and receiver have been described in detail elsewhere by Read[3].

GENERAL RESULTS

The sources investigated are listed in Table I, together with their flux densities and apparent spectral indexes relative to Hydra A. The flux density at 960 Mc/s is based on the value of 67×10^{-26} watts $m^{-2}(c/s)^{-1}$ for Hydra A given by Harris and Roberts[4].

Fifty-three sources were observed on two occasions to give some indication of the internal consistency of our results. For these sources an average of the two observations is given in Table I. Where the agreement between the observations was good (i.e., the two values were within 15 percent of the mean), the flux density is underlined. For the 7 sources where the two observations gave inconsistent results, both measured values are listed at the end of the table. For four of these, the error is about 20 percent; for one, 30 percent; and for the other two, approximately 50 percent. In the case of 18-1<u>3</u>, one of the observations was made near sunrise, which may account for the large discrepancy.

As a check on the stability of the equipment, several strong sources were observed each night. The relative night-to-night ratios of their intensities are within 10 percent of the mean values. It is felt that the flux densities given for the stronger sources are reliable to within 15 percent. Sources near the limit of detection, however, may be in error by as much as 50 percent. This is of the same order of accuracy as quoted in the MSH catalogue.

In analyzing our data, the sources were grouped according to their angular size, intensity, declination, and galactic latitude. Due to the relatively large number of extended objects near the galactic plane that were resolved with the interferometer, no extensive analysis was attempted for those sources lying within 10° of the galactic equator.

The fraction of sources detected at 960 Mc/s in the various groups is shown in Table II. Of the 523 sources with flux density greater than 15×10^{-26} watts $m^{-2}(c/s)^{-1}$ listed in MSH as not having appreciable angular extent, definite evidence was found for 431 (82 percent). The distribution with respect to flux density at 86 Mc/s of those sources not detected at 960 Mc/s is shown in Figure 2: 80 percent are between 15 and 20×10^{-26} watts $m^{-2}(c/s)^{-1}$. While nearly 25 percent of the northern sources (-10° to $+20^{\circ}$) were not found, only 10% of the southern sources (-50° to -20°) were not detected.

It is felt that our failure to detect these sources is due to one or more of the following causes.

1) The spectrum of the source may be steep enough to put it below the limit of detection at our frequency.

2) The source may be extended and thus resolved by the interferometer.

3) The positions given in MSH may contain substantial errors, or perhaps in a rare case an incorrect setting of the telescopes was made in our observations.

4) The source may be spurious. In this respect it is perhaps significant that many of the stronger sources that were not detected lie close to the galactic plane in the vicinity of the center, where the observations are more apt to be confused.

EXTENDED SOURCES

The results for the "extended" or "probably extended" sources are more difficult to interpret. As is well known, an interferometer discriminates against sources whose angular size is comparable to the fringe spacing. Figure 3 indicates that any simple source large enough to be resolved with the Mills cross would be reduced to a few percent of its true intensity with our interferometer. It is therefore somewhat surprising that as many as 60 percent of these sources were detected, although the apparent spectral indexes are unusually steep, possibly indicating resolution with the interferometer.

Observations were also made of 26 "extended" and 30 "probably extended" sources with a 130-foot effective baseline (fringe spacing 28 minutes of arc). The results are as follows.

For 26 extended sources:

a. 10 had approximately equal amplitudes at both spacings;

b. 8 were not detected at either spacing;

c. 4 were detected at 200 feet, but not at 130 feet;

d. 4 were detected at 130 feet, but not at 200 feet.

For 30 "probably extended" sources:

a. 16 had approximately equal amplitudes at both spacings;

b. 5 were not detected at either spacing;

c. 3 were detected at 200 feet, but not at 130 feet;

d. 6 were detected at 130 feet, but not at 200 feet.

Thus it appears that many of these sources are not simple sources of large angular diameter. These conclusions are supported by unpublished results of Moffet, who has determined the east-west diameters of the following sources.

MSH No.	MSH Designation	E-W Diameter (Moffet)
00-0$\underline{9}$	Extended	Two sources $1'.5$ and $1'.0$ Separation 1°
08+0$\underline{3}$	Extended	$3'.5$
14+0$\underline{10}$	Extended	$< 1'.2$
15+0$\underline{2}$	Probably extended	Double, total extent $< 2'.5$
16+0$\underline{1}$	Perhaps extended	Possibly double, total extent $< 6'$
20+0$\underline{10}$	Probably extended	$< 0'.8$
22-1$\underline{7}$	Perhaps extended	$< 0'.7$

The ratios of integrated to peak flux densities given in MSH for the first two sources (listed as extended) are about two to one, implying a diameter of about 50 minutes of arc. In the case of 00-09, two small sources were observed near the position given by MSH. Moffet found 08+03 to have a diameter of 3.5 minutes, while the other five sources listed as "extended", "probably extended", or "perhaps extended" were likewise found to be too small to show resolution with the Mills cross.

SPECTRAL INDEXES

The apparent spectral indexes of all observed sources were calculated assuming a power law of the usual form: flux density is proportional to $(\text{frequency})^x$. The spectral indexes given in Column 4 of Table I are relative to Hydra A, that is $x - x_{\text{Hydra A}}$. Discussion of the results in terms of relative spectral index avoids the question of absolute calibration at either frequency. A comparison of the flux density at 960 Mc/s[4] with that of MSH gives an absolute spectral index for Hydra A of -0.96. However, considerations of other observations of this source over a wide range of frequencies suggests an index close to -0.65.[6,7,8,9,10]

The distribution of relative spectral indexes for the "non-extended" sources away from the galactic plane is shown in Figure 4. Fifty percent of the sources lie within 0.20 of the median value, -0.07, This dispersion is slightly greater than that found by Harris and Roberts from their observations of 3C sources.

The median spectral index for various intensity groups is shown in Table III. The total shift of median spectral index corresponds to a change in the average of the observed intensity ratios by a factor of 1.8. This could be due to an overestimate by MSH of the flux densities of their weaker sources. In their second catalogue, they indicate that the flux densities for the sources with flux density between 15 and 20 x 10^{-26} watts $m^{-2}(c/s)^{-1}$ in the northern zones were overestimated by about 15 percent. The effect observed here, however, requires a substantially greater correction. Alternately, the apparent change in median spectral index could be explained if the average position error of the weaker sources exceeds that of the stronger ones by the order of 20 minutes of arc, thus reducing the apparent flux density at 960 Mc/s.

While it is likely that one or both of these instrumental effects is responsible for the observed result, it is of interest to speculate on the possibility that the effect may be real; that is, the weaker sources actually do have steeper spectra. One possible explanation comes from the suggestion that the spectra of radio sources does not follow a simple power law[11]. If the spectrum tends to get steeper with increasing frequency, as seems to be the case for Cygnus A[12], then we would expect the distant (apparently weak) sources to have steeper observed spectra due to their large red shift.

CONCLUSION

Since the instrument used for this program is quite dissimilar to the Mills cross used for the original survey, it is felt that those sources found at both frequencies must represent valid radio sources and are not due to instrumental effects. The existence of 79 percent of the sources with flux density greater than 15×10^{-26} watts $m^{-2}(c/s)^{-1}$ at 86 Mc/s in the areas investigated is thus confirmed. However, the apparent steepening of the spectra of the weaker sources suggests either systematic effects in the flux density measurements or considerably greater errors in the 86 Mc/s positions than those estimated by the authors.

A log N - log S plot based on the MSH catalogue and on the quoted flux density at 86 Mc/s, omitting the sources which were not confirmed by the 960 Mc/s observations, gives a slope of -2.0 (see Figure 5). This is in good agreement with the results of the Cambridge 3C survey[8], although it should be born in mind that the present observations were also made with an interferometer.

We feel that our observations of the sources listed by MSH as "extended" or "probably extended" indicate that many of these sources are not simple extended objects. It thus appears that the statistical discrepancies that exist between the Cambridge and Sydney surveys might be due to the misinterpretation by the latter of these sources. This problem has been discussed by Bolton[13].

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SOURCE LIST

Table I

No.	S_{86}	S_{960}	R.S.I.	
00+0				
1	35(20)	---	(-.53)	E
2	20	2.2	+.05	
3	18	---	(-.54)	
6	68(20)	0.9	-.27	E
7	25	0.4	-.69	
8	16	0.7	-.29	
9	15	0.9	-.19	
11	37	3.2	-.06	
14	19	0.5	-.52	
15	16	0.4	-.59	
17	19	0.7	-.41	
01+0				
3	33(16)	1.5	.00	E
4	20	0.5	-.59	
5	16	1.8	+.07	
6	18	3.2	+.24	
7	23	2.2	+.01	
8	15	2.5	+.22	
11	19	0.9	-.28	P
12	19	?	(-.57)	P
13	49(27)	1.3	-.32	E
14	16	0.6	-.38	
02+0				
2	23	1.6	-.13	
3	24	0.7	-.45	
5	24	2.6	+.05	
10	51	7.6	+.18	
11	27	1.3	-.31	
03+0				
1	18	1.6	-.03	
3	34	8.6	+.40	
5	41	6.4	+.18	
6	24	?	(-.52)	
8	35	4.2	+.09	
9	15	?	(-.47)	
10	15	4.7	+.49	
11	16	?	(-.38)	
12	19	3.0	+.20	
04+0				
3	37	6.2	+.23	
7	20	2.0	+.03	P
04+0				
8	25	0.7	-.57	P
10	30	1.3	-.35	P
14	15	1.3	-.06	
05+0				
1	16	?	(-.50)	
2	38	3.0	-.09	
3	20	0.7	-.43	
4	17	0.5	-.50	
5	30	4.4	+.17	
7	22	0.5	-.63	P
06+0				
3	109(28)	?	(-.58)	E,G
4	18	---	(-.40)	P,G
6	153(45)	?	(-.76)	E,G
7	18	?	(-.40)	G
8	250(87)	1.9	-.63	E,G
9	29	---	(-.60)	G
10	72(40)	---	(-.73)	E,G
11	27	1.7	-.18	G
12	16	1.4	-.06	G
13	22	---	(-.48)	G
14	24	0.8	-.44	P,G
07+0				
1	11	---	(-.19)	
2	17	---	(-.38)	G
3	21	0.6	-.52	
4	36	2.2	-.20	
08+0				
2	29(22)	1.3	-.19	E
3	125(60)	3.1	-.26	E
4	17	---	(-.38)	
6	17	?	(-.38)	P
9	14	2.0	+.16	
09+0				
2	40	0.6	-.78	
3	24	1.2	-.30	
5	32	4.1	+.12	
7	89	8.8	.00	
8	36	5.5	+.19	
9	16	0.8	-.27	
10	18	1.5	-.07	

No.	S_{86}	S_{960}	R.S.I.	
10+0				
1	30	7.1	+.36	
2	39	5.1	+.10	
5	15	---	(-.32)	
6	35	1.4	(-.38)	
9	21	2.0	-.01	
10	24(14)	1.1	-.32	E
11	19	---	(-.43)	
11+0				
1	16	0.6	-.39	P
2	15	0.8	-.25	
5	19	2.0	+.01	
8	15	2.5	+.23	
13	12	?	(-.22)	P
12+0				
2	25	1.8	-.13	
4	30	2.8	.00	
5	100	17	+.24	
6	24	1.9	-.09	
8	167	48	+.45	
9	16	1.2	-.12	
11	17	1.0	-.21	
13+0				
1	22	1.4	-.19	
2	18	1.4	-.10	
3	22	0.8	-.40	P
5	16	---	(-.34)	
6	50(27)	---	(-.56)	E
7	19	3.9	+.31	
9	13	1.4	+.02	
11	54(22)	?	(-.48)	E
12	19	4.3	+.34	
14+0				
1	28	---	(-.58)	
2	14	?	(-.28)	
3	17	?	(-.38)	
5	114	10	-.04	
6	22	---	(-.48)	
8	16	0.8	-.27	
9	17	2.0	+.06	
10	47(31)	3.5	+.05	E
13	15	---	(-.32)	
14	19	1.0	-.26	
15+0				
1	15	?	(-.32)	
2	42	5.1	+.08	P
3	24	0.9	-.41	
4	20	3.3	+.21	
15+0				
5	140	11	-.08	
6	16	3.1	+.29	
7	50	0.7	-.73	P
9	17	---	(-.38)	
11	22	---	(-.38)	
12	17	1.4	-.09	
13	16	0.9	-.23	
14	18	0.8	-.32	
16+0				
1	100	11	+.05	
2	45	4.9	+.04	
3	35	4.1	+.07	
4	17	---	(-.38)	
5	27	0.8	-.49	
7	22	---	(-.48)	P
8	23	---	(-.50)	
9	33	0.6	-.71	P
10	890	78	-.02	
17+0				
1	78(49)	---	(-.81)	E
2	36	0.5	-.84	P
3	48	?	(-.80)	*
18+0				
1	33	?	(-.65)	P,G
2	27	1	-.36	G
4	41	0.8	-.54	G(1)
5	50(24)	?	(-.52)	E,G
6	45	?	(-.77)	P,G
7	20	1.9	-.48	P,G*
8	54	4.2	-.11	P,G
9	28	0.5	-.68	G*
10	25	---	(-.53)	P,G
11	550	33.4	-.24	P,G
19+0				
1	59	1.6	-.52	P,G
2	29	---	(-.59)	P,G
3	20	---	(-.44)	P,G
4	20	0.4	-.65	G
5	30	1.3	-.32	G*
6	18	1.3	-.13	P,G
7	34	0.9	-.52	P(2)
10	64	6.7	+.12	
20+0				
1	15	?	(-.32)	
4	16	?	(-.34)	
9	19	---	(-.43)	
10	22	3.6	+.21	P

No.	S_{86}	S_{960}	R.S.I.	
20+12	104(23)	0.5	-.64	E
13	19	1.6	-.06	
21+0				
3	17	0.9	-.24	
4	27	3.8	+.21	
5	67(25)	---	(-.53)	E
7	18	1.3	-.12	P
8	15	?	(-.32)	
10	23	0.7	-.50	
11	17	1.9	+.06	
12	15	0.8	-.24	
22+0				
1	26	0.9	-.42	
3	31	0.6	-.67	P
4	8.1	0.7	-.08	
5	16	---	(-.34)	
6	19	0.7	-.43	
9	15	1.3	-.06	
10	17	---	(-.39)	
13	16	0.7	-.34	
14	16	0.5	-.50	
15	15	?	(-.28)	
23+0				
2	22	2.4	+.03	
3	51(29)	3.6	+.10	
4	18	4.2	+.37	
5	57	7.9	+.13	
7	15	?	(-.32)	
8	17	?	(-.38)	

No.	S_{86}	S_{960}	R.S.I.	
00-0				
1	35	1.3	-.38	
2	15	2.0	+.15	
4	23	---	(-.57)	
6	24	1.0	-.34	P
9	120(67)	2.6	-.24	E
11	56	0.7	-.84	
14	18	1.9	+.02	
15	23	2.6	+.19	
17	90(72)	8.0	+.06	E
01-0				
2	15	0.7	-.30	
3	19	1.2	-.18	
4	18	0.4	-.58	
5	88	7.5	-.06	
6	19	?	(-.60)	
8	18	0.8	-.34	
13	20	1.3	-.17	
02-0				
7	74	5.1	-.14	
11	15	1.3	-.05	
13	15	---	(-.67)	
14	35	6.2	+.25	
15	25	---	(-.53)	P
03-0				
1	20	1.9	.00	
3	64	3.6	-.23	
5	16	0.9	-.27	
6	25	3.7	+.18	
8	16	0.5	-.46	
04-0				
2	19	1.7	-.04	
4	17	0.4	-.56	
5	15	---	(-.51)	
6	35	1.8	-.27	
7	36(18)	?	(-.40)	E
8	28	2.1	-.11	
14	17	0.9	-.23	
16	16	0.9	-.21	
17	46(23)	1.1	-.28	E
20	20(12)	0.9	-.12	E
21	18	0.9	-.30	
05-0				
2	16	0.7	-.30	
3	17	5.7	+.51	P
4	18	0.7	-.37	
6	17	1.3	-.11	P
7	16	0.9	-.25	
8	15	0.7	-.30	
10	15	---	(-.38)	

No.	S_{86}	S_{960}	R.S.I.	
06-0				
2	23	1.2	-.28	P,G
3	15	1.3	-.04	G
4	120	29	+.38	G
7	50(25)	0.8	-.48	E,G
8	33	1.6	-.38	P,G
9	17	0.8	-.31	G
11	25	1.6	-.24	G
12	24	1.0	-.32	G
07-0				
2	21	0.6	-.53	G
3	25	1.6	-.17	G
4	36	1.9	-.24	G
5	94(47)	---	(-.80)	E,G
6	29	4.3	+.14	G
8	19	1.4	-.10	
9	15	1.2	-.13	
10	17	---	(-.39)	
13	17	0.8	-.24	
08-0				
2	15	1.8	+.07	
4	22	2.7	+.09	
5	35	3.1	-.04	
6	20	1.0	-.28	P
8	27(19)	0.6	-.48	E
11	13	0.6	-.29	
15	18	2.7	+.09	
09-0				
2	17	0.8	-.28	P
6	15	0.8	-.25	
9	100(28)	---	(-.59)	E
11	12	0.6	-.37	
10-0				
1	17	1.5	-.04	
3	17	1.4	-.09	
5	16	1.0	-.19	
8	17	1.2	-.18	
11	17	1.0	-.23	P
13	16	1.0	-.19	
16	17	?	(-.39)	P
18	20	1.2	-.18	
21	23	4.1	+.23	
11-0				
1	15	1.0	-.14	
5	18	2.5	+.13	
6	16	---	(-.35)	
7	16	---	(-.35)	

No.	S_{86}	S_{960}	R.S.I.	
11-0				
8	31	2.7	-.06	
9	14	1.0	-.11	P
16	24	1.4	-.19	P
17	16	---	(-.35)	P
18	16	---	(-.35)	
12-0				
2	18	0.9	+.27	
7	15	1.2	-.14	
8	15.7	1.1	-.09	
9	23	2.6	+.09	
12	52(24)	?	(-.52)	E
13	25	1.4	-.31	
14	20	---	(-.44)	
18	17	0.8	-.35	
20	37	11	+.45	
13-0				
2	19	4.7	+.37	
3	25	1.0	-.40	
5	45(23)	---	(-.50)	E
7	16	0.8	-.27	
11	35	5.9	+.19	
12	16	1.0	-.27	
13	53(23)	1.6	-.30	E
14-0				
2	18	0.6	-.42	
4	27(17)	---	(-.38)	E
7	24.4	2.9	.00	P
9	16	3.5	.00	
11	25	5.1	+.31	
12	16	?	-.33	
14	22	1.2	-.26	P
15	20	0.8	-.40	P
17	22	3.9	+.17	
18	16	2.2	+.06	
19	19	?	(-.43)	
15-0				
1	18	1.2	-.17	
2	17	?	(-.33)	
3	19	?	(-.43)	
4	18	1.8	-.03	
5	8	4.0	+.56	
10	18	?	(-.40)	
12	37(21)	0.8	-.39	E
14	23	1.0	-.33	
18	19	---	(-.43)	

No.	S_{86}	S_{960}	R.S.I.	
16-0				
1	20	4.9	+.40	
4	15	1.8	-.14	
8	17	0.8	-.27	
10	26	---	(-.55)	
11	21	1.2	-.28	
12	80(50)	?	(-1.04)	E
14	60(26)	0.6	-.57	E
16	15	0.8	-.14	*
17-0				
1	17	---	(-.36)	
3	15	---	(-.32)	*
4	21	2.3	+.01	
5	31	---	(-.63)	
6	475	71	-.17	
7	16	0.8	-.34	
8	15	?	(-.32)	P
9	16	---	(-.34)	
10	19	---	(-.43)	
11	39	0.8	-.64	
12	53	---	(-.87)	
13	21	---	(-.46)	
14	55	1.4	-.67	
15	50	0.9	-.68	P,G
18-0				
8	160	13	-.09	G
19-0				
2	16	0.5	-.50	G
20-0				
13	17	---	(-.39)	P,G
21-0				
7	19	---	-.41	P
9	15	0.5	-.47	
22-0				
14	16	1.0	-.18	
16	20	---	(-.79)	P
19	32(19)	6.5	+.52	E
23-0				
4	14	0.3	-.65	
10	35(19)	0.7	-.43	E
11	19	---	(-.77)	
20	18	2.0	+.06	

No.	S_{86}	S_{960}	R.S.I.	
00-1				
1	28	3.0	+.04	
2	15	?	(-.47)	
4	17	0.9	-.23	
6	34(20)	0.9	-.33	E
7	52(33)	2.2	-.15	E
8	23	1.8	-.07	(3)
15	17	1.4	-.06	
21	18	1.3	-.11	
25	17	0.9	-.26	
26	29	2.8	-.01	
01-1				
1	18	2.0	+.06	
2	53	6.3	+.09	
4	16	1.4	-.04	
9	45	6.6	+.17	
11	30	4.0	+.13	
12	18	---	(-.44)	P
15	28	1.8	-.17	
16	16	0.5	-.50	
20	16	2.5	+.19	
02-1				
2	17	1.5	-.05	
3	30(19)	2.6	+.13	P
5	42	7.9	+.27	
8	19	1.8	-.01	
9	17	1.7	.00	
10	44	6.9	+.20	
14	15	1.3	-.03	
03-1				
1	18	0.8	-.32	
2	17	0.6	-.43	
3	16	0.9	-.21	
5	16	1.9	+.09	
7	34	?	(-.81)	
9	44	4.8	+.05	
10	21	1.8	-.05	
11	18	2.9	+.21	
04-1				
2	31	4.9	+.20	
5	18	---	(-.55)	
6	15	0.8	-.21	
9	16	1.2	-.11	
12	38	3.7	.00	
13	15	0.9	-.15	
19	17	1.5	-.05	

No.	S_{86}	S_{960}	R.S.I.	
05-1				
1	20	1.8	-.03	
2	16	0.5	-.44	
3	41	1.1	-.43	(4)
5	16	2.2	+.14	
6	16	0.8	-.27	
9	16	0.7	-.31	
12	16	0.9	-.24	
14	15	2.2	+.17	
16	15	?	(-.47)	
20	17	1.3	-.07	
22	17	2.3	+.09	
26	13	1.2	-.05	
06-1				
2	15	2.1	+.15	
4	19	---	(-.43)	
5	63(21)	---	(-.46)	E
7	16	---	(-.34)	P,G
8	16	?	(-.34)	
10	18	2.3	+.12	G
11	84(27)	0.8	-.45	E,G
12	18	1.6	-.04	G
13	55(11)	1.0	.00	E,G
07-1				
1	55(28)	0.6	-.60	E,G
3	17	1.0	-.21	P,G
4	25	0.8	-.45	P,G
5	17	---	(-.38)	P,G
6	19	1.8	.00	G
8	17	0.6	-.42	G
9	29(17)	1.4	-.31	E,G
13	12	0.8	-.13	G
17	52	6.2	+.09	G
18	20	0.9	-.31	G
19	17	1.0	-.21	G
08-1				
1	33(18)	0.6	-.70	E
2	18	1.2	-.39	
4	40	7.2	+.28	
6	14	0.9	-.16	
8	14	---	(-.28)	
10	18	1.0	-.22	
12	12	0.9	-.10	
16	24	3.1	+.17	
19	17	2.0	+.05	
09-1				
2	16	0.7	-.34	
3	9.5	1.0	+.03	
4	690	67.2	.00	

No.	S_{86}	S_{960}	R.S.I.	
09-1				
5	11	1.2	+.03	
7	15	---	(-.32)	P
9	50(25)	?	(-.53)	E
11	25(16)	1.4	-.06	E
12	12	1.0	-.04	P
14	14	1.2	-.08	
10-1				
1	7.3	---	(-.03)	
2	32(16)	1.8	+.04	E
3	17	---	(-.38)	P
8	18	1.0	-.22	
11	18	0.6	-.43	
16	14	---	(-.28)	
20	24	2.0	-.08	P
22	9.2	---	(-.11)	
11-1				
1	56(14)	0.6	-.33	E
3	17	0.6	-.42	
4	12	---	(-.22)	
6	32	1.4	-.34	
7	19	2.3	+.08	
8	44	7.0	+.20	
10	25	?	(-.53)	
12	15	---	(-.32)	
13	17	2.5	+.16	
19	16	2.9	+.25	
12-1				
2	48(16)	---	(-.73)	E
3	56(20)	1.2	-.27	E
7	12	---	(-.22)	
9	16	---	(-.34)	
10	38	0.8	-.65	
12	24(12)	---	(-.22)	E
14	18	?	(-.40)	
16	18	1.0	-.22	
18	53	12	+.34	
19	27(14)	1.4	.00	E
20	19	---	(-.43)	
13-1				
1	18	1.4	-.10	
4	22	2.7	+.10	
6	18	1.2	-.16	
7	17	0.9	-.27	
10	18	1.0	-.22	
11	15	---	(-.32)	
14	15	---	(-.32)	
15	18	2.5	+.15	P
18	15	1.2	-.10	P

No.	S_{86}	S_{960}	R.S.I.	
14-1				
2	15	?	(-.32)	
4	34(22)	2.5	-.10	E
6	26(16)	1.0	-.37	E
10	22	2.0	-.04	
14	11	2.1	+.28	
16	14	0.4	+.05	
17	17	---	(-.38)	
18	42(20)	1.4	-.16	E
19	19	2.5	+.13	
21	41	7.2	+.25	P
22	16	1.6	.00	
15-1				
5	15	1.0	-.17	
6	49(30)	---	(-.62)	E
7	19	2.0	+.02	
9	16	2.3	+.20	
11	13	---	(-.26)	
12	16	1.7	-.08	P
15	9.5	1.0	+.16	
17	21(14)	?	(-.28)	E
16-1				
1	16	2.9	+.24	
4	15	0.4	-.50	
5	11	---	(-.19)	
6	17	---	(-.38)	
8	20	5.5	+.42	
9	15	---	(-.32)	
11	15	1.4	-.03	
13	16	1.0	-.14	
15	23	1.1	-.30	
16	19	0.8	-.34	*
17	30	1.6	-.26	
18	18	0.8	-.32	
19	37	2.5	-.14	
21	17	---	(-.38)	
22	22	1.1	-.28	
17-1				
1	15	1.4	-.02	
2	60(35)	1.4	-.70	E
3	32	---	(-.64)	P
4	16	---	(-.34)	P
5	15	---	(-.32)	
6	150(50)	?	(-.79)	E
7	21	0.9	-.15	
8	16	---	(-.34)	G
9	18	---	(-.40)	G
10	30	1.0	-.44	P,G*
11	19	1.0	-.26	G
12	16	---	(-.34)	P,G
14	24	6.0	+.04	G

No.	S_{86}	S_{960}	R.S.I.	
18-1				
1	40	---	(-.73)	G*
2	29	0.5	-.69	P,G (5)
3	160	5.3	-.44	G*
4	20	1.1	-.24	G*
5	35	2.8	-.12	P,G*
6	15	0.9	-.19	G*
7	40	1.5	-.38	G*
8	150	13.3	-.03	G
9	50	9.1	+.69	G
10	15	0.7	-.32	G*
11	40	1.5	-.40	G*
12	30	1.6	-.24	G*
13	230	5.3	-.60	G
14	56(28)	0.9	-.47	G,E*
15	24	?	(-.51)	P
16	23	1.1	-.28	G
17	15	0.7	-.28	P
19-1				
1	20	?	(-.45)	
2	17	---	(-.36)	
6	28	1.1	-.38	
7	23	2.2	.00	
8	22	2.0	-.03	
9	12	---	(-.22)	
10	75(34)	0.8	-.60	E
11	38	7.9	+.30	*
13	15	0.7	-.28	
15	18	1.5	-.08	P*
16	19	0.7	-.38	
20-1				(6)
1	15	1.5	.00	
6	20	2.3	+.06	
7	15	0.7	-.28	
11	15	1.1	-.14	
13	17	---	(-.37)	
18	24	1.8	-.11	
21-1				
1	14	?	(-.28)	
3	10	---	(-.14)	
7	17	0.4	-.59	
9	30	1.9	-.17	P*
11	15	0.7	-.32	
13	15	---	(-.32)	
14	28	---	(-.57)	
15	33	4.4	+.13	
16	23	0.9	-.36	
17	16	1.1	-.13	
19	25(13)	1.9	+.16	E
21	18	2.4	+.13	P

No.	S_{86}	S_{960}	R.S.I.	
21-1				
22	8.8	0.9	.00	
23	25	1.1	-.33	
22-1				
1	16	5.4	+.51	*
6	16	1.3	-.08	
7	127	13.5	.00	
9	15	1.2	-.08	
10	15	0.7	-.28	
14	16	2.2	+.16	
15	17	3.2	+.26	
16	17	0.7	-.35	
22	6.7	---	(.00)	
23-1				
8	23	3.2	+.16	
9	15	0.8	-.22	
12	30	3.2	+.04	
14	19	1.5	-.06	
19	16	0.7	-.34	
21	16	3.4	+.63	

No.	S_{86}	S_{960}	R.S.I.	
00-2				
7	21	3.8	+.26	
9	33	5.2	+.19	
10	17	0.7	+.62	P
16	19	2.2	+.08	
22	29	7.1	+.38	
01-2				
1	35	0.7	-.62	
2	16	1.4	-.03	
6	24(18)	5.8	+.48	E
11	18	2.3	+.11	
15	16	2.6	+.21	
17	63(43)	6.0	+.15	E
02-2				
2	16	1.1	-.12	
5	15	2.2	+.16	
7	19	3.2	+.22	
11	17	1.9	+.06	
19	28	3.1	+.08	
03-2				
2	17	2.9	+.23	
3	23	2.2	-.09	
4	15	0.7	-.27	
10	15	1.5	+.01	
12	53	9.4	+.25	
04-2				
3	17	2.2	+.12	
4	26	4.6	+.25	
8	15	1.2	-.07	P
18	82	13.8	+.23	
19	19	0.7	-.36	
21	38(21)	2.3	+.05	E
22	18	6.4	+.60	(7)
23	7	?	(.00)	
05-2				
2	60(30)	3.6	+.08	E
3	19	3.5	+.26	P
4	19	1.7	-.02	

No.	S_{86}	S_{960}	R.S.I.	
17-2				
12	21	0.7	-.45	G
13	4500	25.2	(a)	E,G
14	194(87)	?	(-1.05)	E,G
15	82	1.0	-.86	P,G
16	900	16.8	-.69	G
17	35	9.1	+.55	G
18-2				
1	253	3.4	-.82	G
2	19	1.3	-.14	G
3	70	3.9	-.23	G
4	34	?	(-.66)	G
5	114(71)	1.6	-.61	E,G
19-2				
3	53	?	(-.85)	P
5	18	2.3	+.12	
20-2				
12	18	3.5	+.28	
22-2				
1	23(14)	1.3	.00	E
7	8	0.6	-.12	
23-2				
4	23	4.7	+.31	
8	20	2.8	+.15	
9	27(16)	?	(-.34)	E
11	15	0.7	-.28	
13	16	1.7	+.09	

(a) Sgr. A -- Complex distribution - no peak value given

No.	S_{86}	S_{960}	R.S.I.	
00-3				
1	17	0.7	-.34	
5	19	2.6	+.13	
6	17	1.1	-.17	
8	20	2.2	+.05	
13	30	2.4	-.10	
16	15	?	(-.38)	
01-3				
5	30(15)	1.9	+.10	E
6	17	0.8	-.29	
8	19	1.9	+.02	
11	56	3.1	-.23	P
12	15	---	(-.38)	
14	16	2.0	+.10	
15	26	5.6	+.34	
02-3				
3	29	1.1	-.38	P
4	19	0.7	-.48	
7	8	---	(-.12)	
03-3				
1	950(825)	12.6	-.77	E
3	23	3.6	+.19	
6	33	3.6	+.05	
04-3				
3	16	1.8	+.06	
6	35	2.0	-.21	
12	18	0.6	-.46	
14	78(43)	2.9	+.34	E
05-3				
5	29	3.8	+.12	
6	66	20.9	+.49	
7	18	1.8	+.01	
10	30(16)	0.8	-.26	E
18	16	1.7	+.04	
19	20	1.2	-.19	

No.	S_{86}	S_{960}	R.S.I.	
17-3				
7	120	4.2	-.20	G
8	95	1.7	-.69	G
9	165	12.0	-.14	G
10	31	0.5	-.77	G
18-3				
3	41	4.6	+.06	
4	18	0.7	-.42	
5	19	?	(-.59)	
7	15	0.8	-.24	
8	17	0.7	-.40	
19-3				
1	18	0.5	-.50	
2	16	0.9	-.22	
3	16	1.1	-.15	
5	45	2.6	-.22	
20-3				
1	17	---	(-.38)	P
2	17	0.9	-.23	
4	15	1.3	-.06	P
5	18	---	(-.57)	
7	41	7.1	+.24	
8	19	1.0	-.25	P
21-3				
4	15	3.0	+.33	
22-3				
5	21	3.6	+.23	
23-3				
3	16	0.8	-.28	
4	24	1.3	-.23	
7	39	2.6	-.17	

No.	S_{86}	S_{960}	R.S.I.	
00-4				
2	17	2.2	+.11	
3	60(31)	2.8	-.05	E
10	35	4.9	+.15	
11	52	12.2	+.36	
13	16	2.3	+.17	
14	23	4.2	+.26	
01-4				
1	41	4.4	+.03	
2	25(17)	1.3	-.09	E
5	34	3.5	+.02	
8	33	0.9	-.54	P
9	18	3.0	+.21	
02-4				
2	16	0.6	-.41	
3	65(31)	4.0	+.12	E
5	17	4.4	-.48	
7	24(14)	0.9	-.14	E
10	12	1.5	+.07	
13	16	1.5	-.02	P
03-4				
3	19	3.8	+.30	
4	14	2.0	+.17	
8	9	0.5	-.29	
10	8	0.6	-.25	
04-4				
2	17	1.6	-.01	
7	13	0.9	-.12	
10	13	1.0	-.09	
05-4				
2	41	6.1	+.18	
3	570	58.7	+.02	
5	19	0.9	-.31	
6	16	2.9	+.26	
7	15	0.9	-.21	
9	17	1.3	-.09	
10	31	4.4	+.16	P

No.	S_{86}	S_{960}	R.S.I.	
17-4				
7	12	0.7	-.24	P,G
8	30	1.0	-.44	P,G
18-4				
1	77(45)	?	(-.11)	E
2	16	?	(-.24)	*
3	41	5.0	+.09	
4	22	4.0	+.25	
19-4				
3	17	1.1	-.14	
4	17	?	(-.55)	
6	141	19.5	+.15	
10	38	1.9	-.27	P
13	31	4.2	+.13	P
20-4				
2	15	1.3	-.07	P
5	22	1.6	-.12	
8	16	0.9	-.24	
21-4				
1	15	?	(-.67)	
7	37	4.5	+.09	
22-4				
3	28	2.6	-.01	
6	42	5.9	+.15	
23-4				
3	15	4.6	+.47	
4	50	6.9	+.14	

Notes to Table I

Column I gives the source number, keeping the same notation used in the Sydney catalogue.

The next two columns list the flux density in units of 10^{-26} watts m^{-2} $(c/s)^{-1}$. The 86 Mc/s intensity is taken directly from MSH. Integrated intensities followed by peak values in parenthesis are given for the extended sources. The 960 Mc/s intensity is based on a value of 67.2×10^{-26} watts m^{-2} $(c/s)^{-1}$ for Hydra A. A dash indicates no evidence was found for the source at the given position; doubtful cases are noted by a question mark. It is estimated that about half of these doubtful sources have a flux density greater than 0.5×10^{-26} watts m^{-2} $(c/s)^{-1}$. If the source was observed twice, giving agreement within 15% of the mean value, the intensity is underlined.

The fourth column gives the apparent spectral index relative to Hydra A, that is $X - X_{Hydra\ A}$. The values given for the extended sources are based on the peak flux density at 86 Mc/s. If the source was not detected, an upper limit for the spectral index was determined and is indicated in parenthesis.

The final column indicates whether the source is extended (E), probably extended (P), and whether within 10^{o} of the Galactic plane (G). If the intensity measurement in MSH is listed as uncertain, an asterisk is placed in the last column. The seven cases where good agreement was not obtained between two observations at 960 Mc/s are listed below. They are referred to in the last column of the table by number.

	Source	Observation No. 1	Observation No. 2
(1)	18+0$\underline{4}$	0.6	1.1
(2)	19+0$\underline{10}$	5.2	8.2
(3)	00-1$\underline{8}$	1.5	2.1
(4)	05-1$\underline{3}$	0.9	1.4
(5)	18-1$\underline{3}$	8.2	2.4
(6)	20-1$\underline{1}$	1.5	?
(7)	04-2$\underline{22}$	5.2	7.5

Table II

Summary of Results

	$\lvert b\rvert > 10°$	$\lvert b\rvert < 10°$	Total
Extended Sources	$\frac{34}{51} = 67\%$	$\frac{10}{20} = 50\%$	$\frac{44}{71} = 62\%$
Probably Extended Sources	$\frac{45}{61} = 74\%$	$\frac{17}{27} = 63\%$	$\frac{62}{88} = 70\%$
Other Sources	$\frac{381}{465} = 82\%$	$\frac{50}{58} = 86\%$	$\frac{431}{523} = 82\%$
Total	$\frac{460}{577} = 80\%$	$\frac{77}{105} = 73\%$	$\frac{537}{682} = 79\%$

Grand Total $\frac{571}{739} = 77\%$

Table II shows the number of sources found compared to the number investigated in each category. The first two rows include those sources listed by MSH as extended or probably extended, while the third row gives the remaining sources. The last row is the sum of the first three. All sources investigated with flux density at 86 Mc/s greater than 15×10^{-26} watts m^{-2} $(c/s)^{-1}$ are included in the table. A grand total is also given which includes 57 sources below this limit.

Table III
Median Spectral Indices
$|b| > 10^{\circ}$

960 Mc/s Flux Density Relative to Hydra A		No. of Sources	Median Spectral Index Relative to Hydra A
Point Sources			
>.06		36	+.10
.05 - .06		34	+.01
.04 - .05		26	+.03
.03 - .04		54	-.07
.025 - .03		111	-.09
.022 - .025		120	-.15
	Total	381	-.07
Probably Extended Sources	Total	45	-.15
Extended Sources	Total	34	-.29

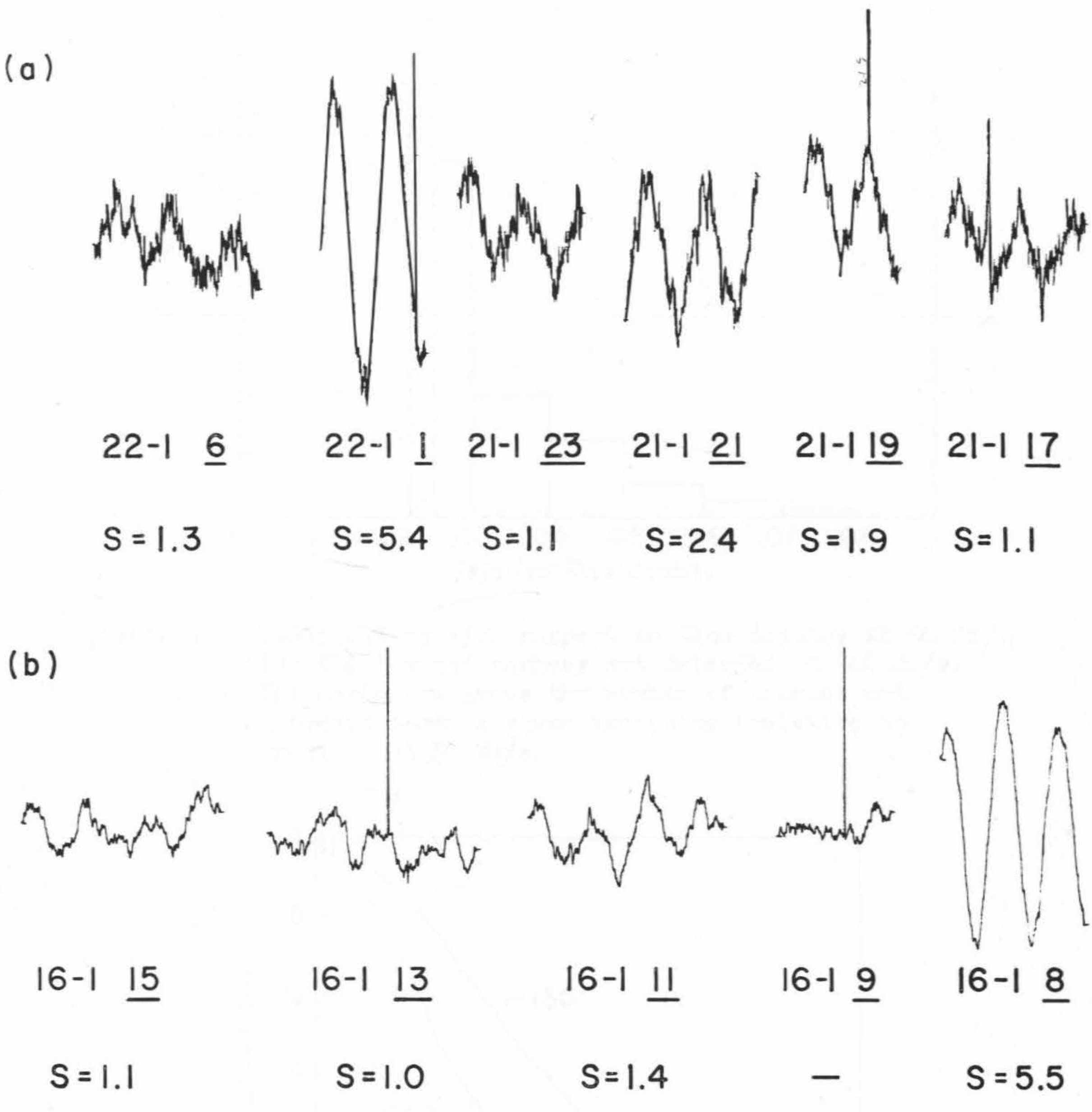

Figure 1 Sample records. The vertical lines indicate 10 minute time markers. Intensity - 10^{-26} wm^{-2} $(c/s)^{-1}$.
a) Time constant: 7 seconds
b) Time constant: 20 seconds

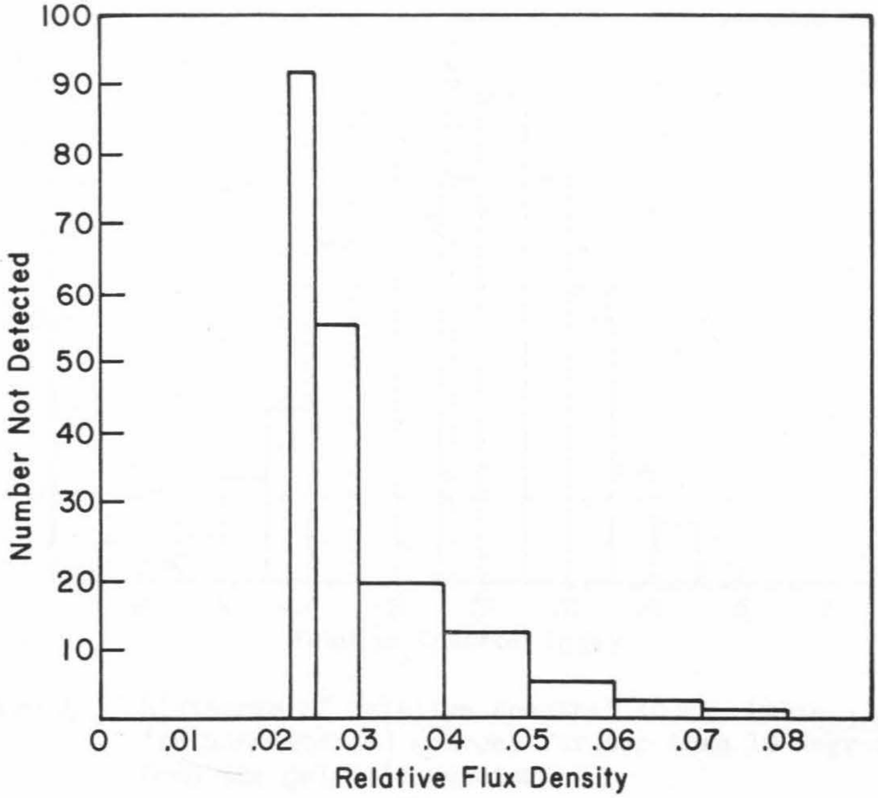

Figure 2 Distribution with respect to flux density at 86 Mc/s for the "point" sources not detected at 960 Mc/s. The histogram shows the number of sources not detected above a given intensity (relative to Hydra A) at 86 Mc/s.

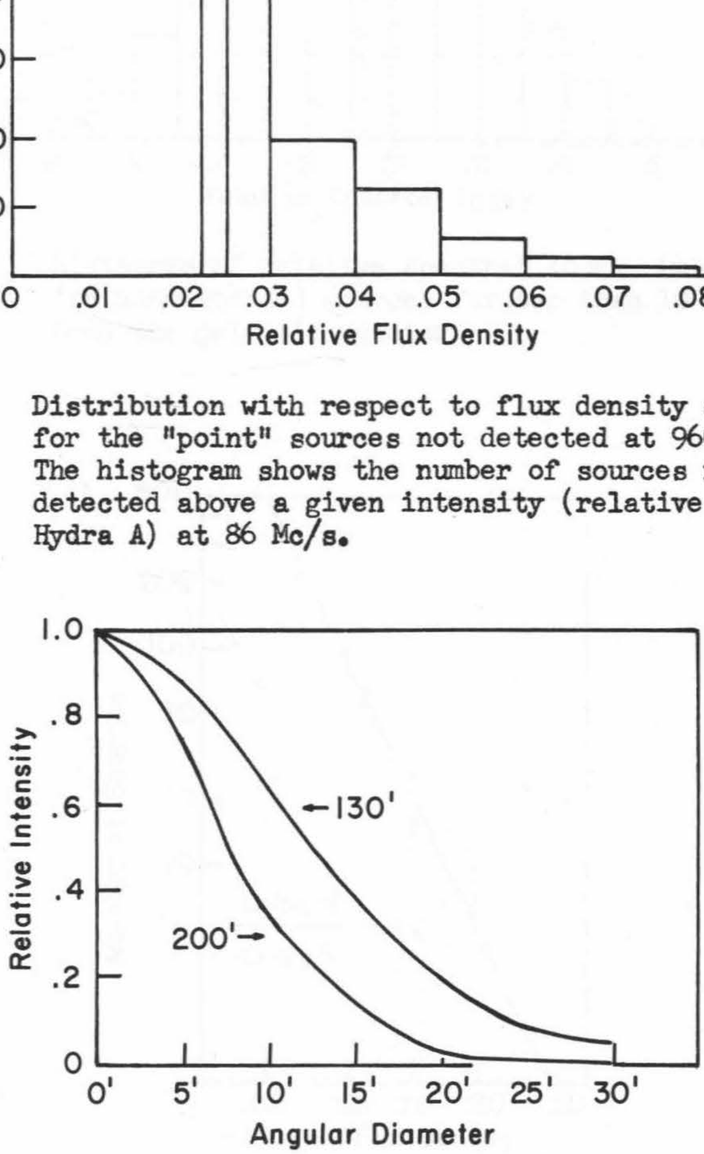

Figure 3 Relative response of a circular gaussian source at antenna spacings of 200 feet and 130 feet. The diameter referred to is that at which the flux density is one half of the peak value.

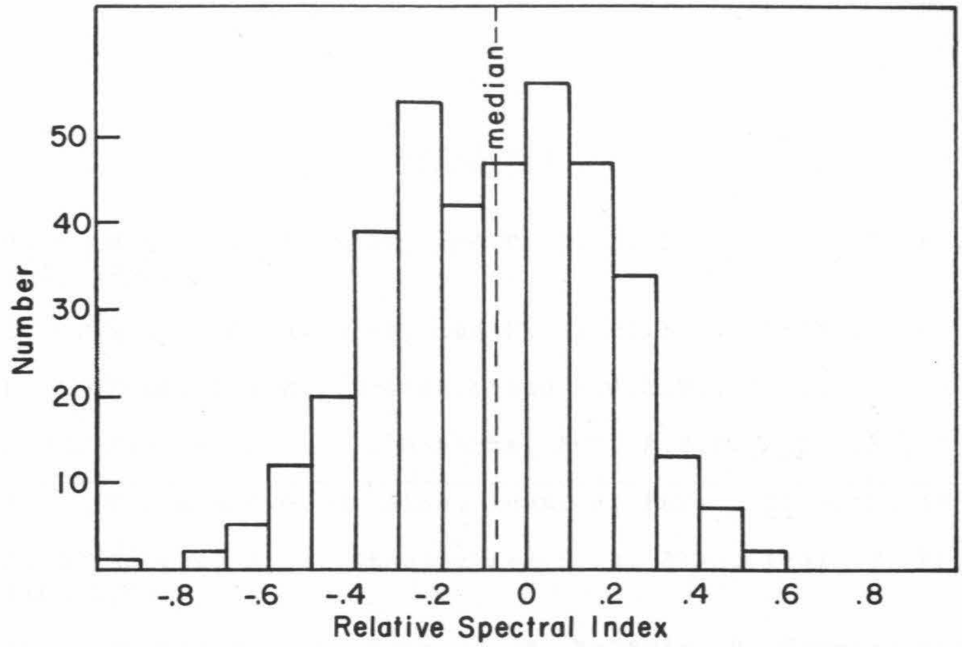

Figure 4 Histogram of relative spectral index, ($x - x_{Hydra\ A}$) for non-extended sources further than 10 degrees from the galactic equator.

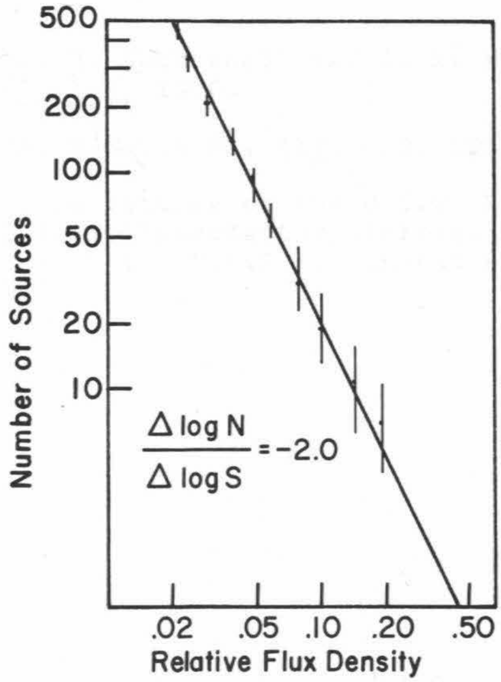

Figure 5 Log N vs log S plot for all "non galactic" sources ($|b| > 10^{o}$) detected at 960 Mc/s. S = 86 Mc/s flux density relative to Hydra A. N = The number of sources with flux density greater than S.

REFERENCES

1. B. Y. Mills, O. B. Slee, and E. R. Hill, Aust. J. Phys., 11, 360, 1958.

2. B. Y. Mills, O. B. Slee, and E. R. Hill, in press.

3. R. B. Read, I.R.E., Transactions P.G.A.P., 1961.

4. D. E. Harris and J. A. Roberts, Pub. A.S.P., 72, 237, 1960.

5. B. Y. Mills and O. B. Slee, Aust. J. Phys., 10, 162, 1957.

6. J. G. Bolton, G. J. Stanley and O. B. Slee, Aust. J. Phys., 7, 110, 1954.

7. J. R. Shakeshaft, M. Ryle, J. E. Baldwin, B. Elsmore and J. H. Thompson, Mem. R.A.S., 67, 106, 1955.

8. D. O. Edge, J. R. Shakeshaft, W. B. McAdam, J. E. Baldwin and S. Archer, Mem. R.A.S., 68, 37, 1959.

9. J. H. Piddington and H. G. Trent, Aust. J. Phys., 9, 74, 1956.

10. C. L. Seeger, G. Westerhout and R. G. Conway, Ap. J., 126, 585, 1957.

11. R. G. Conway, J. R. Shakeshaft and G. R. Whitfield, The Observatory, 80, 162, 1960.

12. G. R. Whitfield, M.N.R.A.S., 117, 680, 1957.

13. J. G. Bolton, Observations of the C.I.T. Radio Observatory, No. 5, p. 6, 1960. (Introductory talk at the session on discrete sources at the U.R.S.I. General Assembly, London, September 1960.)